

# AIR CONDITIONING

# SERVICE CERTIFICATION

## Certification Information

**Scope** - Tests a candidate's knowledge of the installation, service, maintenance, and repair of HVAC systems. System sizes are limited to 30 tons or less cooling capacity.

## Qualifications

- Y This is a test and certification for **TECHNICIANS** in the HVAC industry. The test is designed for top level service technicians. This test for certification is not intended for the HVAC system designer, sales force, or the engineering community. To become NATE-certified, you must pass this specialty and a **CORE SERVICE exam**.
- Y This test will measure what 80% of the **Air Conditioning** candidates have an 80% likelihood of encountering at least once during the year on a **NATIONAL** basis.
- Y Suggested requirement is two years of field experience working on Air Conditioning systems as a service technician and technical training for theoretical knowledge.

## Test Specifications

**Closed Book    2.5 Hour Time Limit    100 Questions    Passing Score: PASS/FAIL**

Listed are the percentages of questions that will be in each section of the **Air Conditioning** exam.

<b>SECTION AREA DESCRIPTION</b>	<b>SECTION PERCENTAGE</b>
Installation	15%
Service	45%
System Components	25%
Applied Knowledge	15%

## Air Conditioning Industry References

The reference materials listed below will be helpful in preparing for this exam. These materials may **NOT** contain all of the information necessary to be competent in this specialty or to pass the exam.

- American National Standards Institute (ANSI) / Air Conditioning Contractors of America (ACCA) Manuals - Latest Edition
  - “D”, “J”, “QI” - Quality Installation, and “S”
- ACCA Manuals “T” and “RS” - Latest Editions
- ACCA Residential Duct Diagnostics and Repair - Latest Edition
- AHRI-Hydronics Section-IBO/RAH Latest Edition
- International Energy Conservation Code - Latest Edition with Addendum
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems developed by Consortium for Energy Efficiency (CEE) - Latest Edition with Addendum
- ASHRAE Standard-62.2 - Latest Edition with Addendum
- ANSI / ASHRAE Standard-152-2004 - Latest Edition with Addendum
- ENERGY STAR™ Home Sealing Standards - Latest Edition with Addendum
- Duct Calculators – Sheet Metal, Ductboard, and Flexible Duct
- American National Standards Institute (ANSI) / Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
  - HVAC Duct Construction Standards - Metal and Flexible
- Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
  - Fibrous Glass Duct Construction Standards, Residential Comfort System Installation Standards Manual, and HVAC Air Duct Leakage Test Manual
- Air Diffusion Council Flexible Duct Performance & Installation Standards
- North American Insulation Manufacturers Association (NAIMA) Manuals
  - Fibrous Glass Duct Construction Standards and A Guide to Insulated Air Duct Systems
- International Fuel Gas Code – Latest Edition with Addendum
- National Fuel Gas Code – Latest Edition with Addendum

## Passing Score Development Process

The passing scores for the NATE tests were established using a systematic procedure (a Passing Score Study). This procedure employed the judgment of experienced HVAC professionals and educators representing various HVAC specialties and geographical areas. The passing scores were set using criteria defining competent performance. The passing score for different test forms may vary slightly due to the comparative difficulty of the test questions.

## Exam Copyrights

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# Air Conditioning - Air to Air

## Service

### *INSTALLATION*

#### FABRICATING COPPER TUBING

#### REFRIGERANT LINE INSTALLATION

- Locating, mounting, and routing
- Understanding limitations of length and diameter

#### BENDING COPPER TUBING

- Making a proper bend with spring benders
- Making a proper bend with cam type benders

#### COPPER TUBING PREPARATION

- Cutting copper tubing
- Reaming copper tubing
- Cleaning copper tubing
- Swaging copper tubing

#### BRAZING

- Overview of brazing copper to copper
- Oxyacetylene brazing
- Using air / fuel to solder
- Use of purging gas when brazing
- Overview of brazing copper to brass
- Overview of brazing copper to steel
- Selection of brazing materials

#### FLARE FITTINGS

- Making a flare fitting - single and double
- Installing with flare fittings

#### BRAZING & SOLDERING EQUIPMENT

- Brazing products - rods, flux, etc.
- Oxyacetylene brazing equipment
- Gas purging equipment in field brazing
- Air / Fuel systems - acetylene, propane, MAP, etc.
- Soldering products - solder, flux, and torches
- Tool maintenance and care

#### INSTALLING CONDENSING UNIT

#### INSTALLING AND CONNECTING CONDENSING UNIT

- Locating unit
- Preparing site
- Placing unit
- Wiring outdoor units
- Installing refrigerant lines

#### INSTALLING PACKAGED UNITS

#### INSTALLING AND CONNECTING

- Locating equipment
- Preparing site
- Lifting unit
- Sealing unit
- Wiring

#### INSTALLING INDOOR EQUIPMENT

#### INSTALLATION OF INDOOR AIR HANDLERS / FURNACES

- Installing coil and air handler / furnace
- Connecting ductwork
- Connecting refrigerant lines
- Connecting condensate lines
- Wiring air handler / furnace
- Wiring thermostats
- Wiring electronic air cleaners
- TEV's - installation
- Installing fixed metering devices
- Bulb location selection for TEV's

- Auxiliary heat
- Handling - lifting, hanging
- Trapping for condensate lines

## EVACUATION & CHARGING

### SAFE HANDLING OF REFRIGERANT CONTAINERS

- Disposal
- Securing refrigerants for transport
- Signage and documentation for refrigerants
- Proper storage
- Proper container filling

### EVACUATION

- Overview - use of a vacuum pump
- Overview - use of a micron gauge
- Use of a manifold gauge set in evacuation
- Deep single evacuation process
- Removing core of access valves

### LEAK CHECKING & DETECTION

- Overview of leak checking and detection
- Leak checking with electronic leak detectors
- Leak checking with soap solutions
- Gas pressurization for leak checking
- Leak checking with ultrasonic leak detectors
- Leak checking with ultraviolet leak detectors

### CHARGING METHOD

- Weigh in method
- Superheat method and where used
- Subcooling method and where used
- Charging blended refrigerants
- Liquid charging

## DUCT INSTALLATION

### DUCT FABRICATION EQUIPMENT

- Ductboard tools - 90 V-groove, end cutoff, female shiplap, hole cutter, stapler, etc.
- Flex tools - tensioning strap tools, knives, etc.
- Metal tools - metal snips, sheers, benders, breaks, hand formers, calipers, rulers, stapler, etc.

### INSTALLING METAL DUCT

- Assembly methods for rectangular duct
- Assembly methods for round duct
- Hanging ductwork
- Sealing metal duct
- Insulation - internal and external

### INSTALLING FLEXIBLE DUCT

- Assembly methods - appropriate length
- Hanging flexible duct
- Sealing flexible duct

### INSTALLING DUCTBOARD

- Assembly methods for ductboard - supports
- Hanging methods for ductboard
- Sealing ductboard

### INSTALLING GRILLES, REGISTERS, DIFFUSERS, & DAMPER

- Mounting to ductwork
- Securing methods
- Sealing methods

### CHASES USED AS DUCTS

- Floor joists as air ducts
- Vertical chases

### RECONNECTING DUCT WHEN REPLACING EQUIPMENT

- Reconnecting metal duct
- Reconnecting flexible duct
- Reconnecting ductboard duct

### INSTALLATION OF PLENUMS AND DUCT

- Sizing plenums for physical fit
- Types and styles of plenums selected
- Insulation of plenums and ducts

#### INSTALLING ACCESSORIES

##### INSTALLING THERMOSTATS

- Locating and mounting
- Wiring electromechanical thermostats
- Wiring electronic thermostats
- Setting anticipators when used
- Installing air side low ambient control

##### INSTALLING ELECTRONIC AIR CLEANERS

- Installing to a unit - sealing
- Wiring
- Controlling electronic air cleaners

##### INSTALLING ECONOMIZERS

- Installing
- Wiring
- Controlling economizers

#### FIELD WIRING

##### WIRING UNITS & CONTROL WIRING

- Connecting electrical power
- Connecting control circuits
- Meeting manufacturer sizing requirements - wire sizing (size and number)

#### START-UP AND CHECKOUT

##### PRE-START PROCEDURES

- Surveying installation
- Visual connections - tightness, etc.
- Set dip switches / jumpers on ECM motors
- Set speed taps on multi-speed motors
- Set adjustable pulleys on belt driven blowers
- Ensure clean filter is in place and accessible
- Ensure condensate line is flowing

##### START-UP PROCEDURES AND CHECKS

- Surveying installation - checking equipment match
- Supply voltage checks
- Motor checks
- Checking sequences
- Check fan rotation
- Check scroll compressor rotation - high noise level, etc.
- Start-up checklist and preparation
- Metering Device - refrigerant circuit checks
- Airflow checks
- Pressure checks
- Temperature checks - dry bulb, wet bulb, etc.
- Captube refrigerant circuit checks
- Capacity checks

##### LEAK DETECTION TOOLS

- Soap solution
- Electronic leak detectors
- Ultrasonic leak detector
- Halide leak detector
- Use of dye leak detectors
- Pressurization for leak detection
- Meter calibration and maintenance

#### REFRIGERANT CIRCUIT TOOLS

##### MANIFOLD GAUGE SET

- Manifold gauge set
- How to read the gauge set
- How to connect the gauge set for different purposes
- Types and styles of gauge sets

- Using the gauge set for diagnostics
- Low loss fitting connections
- Gauge calibration and maintenance

#### EVACUATION TOOLS

- Vacuum pump
- Micron gauge
- Valve opening tools - core removers, etc.
- Gauge calibration and maintenance

#### CHARGING TOOLS

- Charging scales
- Gauge calibration and maintenance

#### RECOVERY / RECYCLING MACHINES

##### RECOVERY MACHINES

- Introduction to recovery machines
- Types and styles of recovery machines
- Typical recovery procedures
- Recovery machine maintenance and cylinder maintenance

##### RECYCLING MACHINES

- Introduction to recycling machines
- Types and styles of recycling machines
- Typical recycling procedures
- Recovery machine maintenance and cylinder maintenance

#### AIRFLOW MEASUREMENTS

##### AIRFLOW VELOCITY MEASUREMENTS

- Pitot tube and manometer in measuring static pressure
- Discharge velocity equipment
- Velometer - electronic and mechanical
- Anemometer
- Velocity measurement procedures
- Gauge calibration
- Introduction to airflow in Residential HVAC
- Velocity

##### AIRFLOW PRESSURE MEASUREMENTS

- Overview of static pressure measurements
- Inclined manometer
- Diaphragm type differential pressure gauge U-tube manometer
- Electronic manometer / pressure measurement
- Gauge / meter calibration
- Absolute vs. Gauge Pressure
- Static pressure
- Air pressure measurement terminology
- Velocity pressure
- Total pressure

##### AIR VOLUME MEASUREMENTS

- Airflow hood
- Formulae for determining CFM of air
- Formulae for weight of air
- Locations for air volume measurements
- Airflow volume - CFM / SCFM (Static CFM)

#### *SERVICE*

##### PLANNED MAINTENANCE

##### MECHANICAL PLANNED MAINTENANCE

- Filters
- Charge
- Lubrication
- Outdoor coil care
- Indoor coil care
- Packaged unit cabinet care
- Ducts

- Diffusers, grilles, and registers
- Performance checks - temperature rise
- Fan blades / blower scroll

#### ELECTRICAL PLANNED MAINTENANCE

- Electric motor checks
- General wiring checks - tightness of connections, aluminum wire, etc.
- Sequence of operation checks
- Compressor checks, voltage, current
- Crankcase heater check

#### DIAGNOSTICS

##### PRELIMINARY SYSTEM DIAGNOSTICS

- Outdoor unit checks
- Indoor unit checks
- Wiring checks
- Refrigerant line checks
- Thermostat checks
- Condensate drain checks
- Accessories
- Attic ventilation

##### ANALYZING REPORTED SYMPTOMS

- No cooling
- Low capacity
- Humidity problems
- Compressor start problems
- Noise problems
- No heating
- Drafty - cold air
- System runs continuously
- High utility bills
- Air quality
- Wide swings in room temperatures

##### SYSTEM AIR SIDE DIAGNOSTICS

- Temperature checks - dry bulb, wet bulb, etc.
- Airflow checks
- Static pressure checks - noise problems and drafts
- Ductwork - supply checks
- Ductwork - return checks

##### REFRIGERANT SYSTEM DIAGNOSTICS

- Overview
- Using superheat
- Using subcooling
- Analyzing overall refrigerant circuit performance
- Locating problems based on refrigerant circuit temperatures

##### ELECTRICAL CHECKS

- Supply voltage checks
- Compressor circuits
- Condenser fan circuits
- Indoor blower circuits
- Wall thermostat circuits
- Transformer circuits
- Indoor auxiliary heat circuits
- Electronic controllers - input / output

##### COMPONENT CHECKS - ELECTRICAL

- Compressor
- Thermostat
- Crankcase heaters
- Low ambient controls for cooling
- Transformers
- Overcurrent protection
- Relays and contactors

- Pressure controls
- Condenser fan motors
- Indoor blower motors
- Capacitors
- Start relays
- Solenoid valves coils

#### REPAIR

- Refrigerant circuit on coils
- Ductwork
- Electrical wiring

#### REPLACEMENTS

- Outdoor units
- Compressors
- Outdoor fans
- Indoor coils
- TEV's
- Transformers
- Liquid line filter-driers
- Relays and contactors
- Fixed orifice piston / drilled type metering devices
- Indoor blowers
- Capacitors

#### SYSTEM CLEANUP AFTER COMPRESSOR ELECTRICAL FAILURE

- Compressor
- TEV's
- Acid test

#### COMPONENT CHECKS - REFRIGERATION

- Compressor
- TEV's
- Filter-drier
- Suction line - oil traps, risers, etc.
- Liquid line - vertical height, static pressure loss, etc.
- Solenoid valves
- Condensate drains
- Check valves
- Evaporator and condenser coils
- Fixed orifice metering devices / piston

#### OVERVIEW OF ELECTRICAL TROUBLESHOOTING

##### LOW VOLTAGE CIRCUITS

- Voltage tests
- Control string analysis
- Understanding the logic of low voltage troubleshooting
- Troubleshooting equipment with electronic devices.
- Troubleshooting with schematics
- Troubleshooting without schematics
- Current tests
- Equipment continuity tests
- Ground tests

##### LINE VOLTAGE CIRCUITS

- Voltage tests
- Current tests
- Component tests
- Circuit tracing line voltages
- Troubleshooting with schematics
- Troubleshooting without schematics
- Equipment continuity tests
- Ground tests

#### RETROFITTING

##### EQUIPMENT COMPONENT RETROFITTING

- Changing out an outdoor unit

- Changing out an indoor unit
- Matching split system components - efficiency and capacity
- Modifying ductwork for replacement equipment

#### AIR BALANCING

##### GATHERING DESIGN INFORMATION

- Interpreting system design
- Interpreting specifications
- Interpreting equipment information
- Interpreting control data
- Modifying system design

##### PREPARATION OF SYSTEM FOR AIR TESTS

- Locating registers, grilles, equipment, controls, and dampers in building walkthrough
- Setting dampers for tests
- Setting thermostat for tests
- Checking for proper fan operation and rotation
- Checking for proper static pressure and temperature

##### PROCEDURES FOR CONDUCTING AIR TESTS

- Measurements of each supply outlet - total readings
- Measurements of each return inlet - total readings

##### MAKING ADJUSTMENTS

- Adjust airflow to achieve required total airflow
- Re-measure total supply and return grille airflow
- Adjust dampers to obtain design airflow
- Re-measure total airflow to verify that it is within +/- 10%

##### FINAL TEST

- Comparing manufacturer's equipment information with test results
- Record sheave, pulley, and belt sizes data
- Test and record full load motor amperes
- Test and record voltage
- Test and record motor and fan RPM
- Test and record supply and return static pressures
- Test and record supply and return air temperatures - heat and cool

##### COMPLETION OF APPROPRIATE FORMS

- HVAC system report
- System diagrams
- Duct traverse or data pulley forms
- Instrument list - including calibration dates

#### BASIC HVAC SYSTEM ANALYSIS

##### NOISE PROBLEMS

- Interpreting supply / return air volume
- Interpreting supply / return air velocity
- Noise problems
- Blower cavitation
- Oil canning
- Motor / belt noise
- Vibration

##### HIGH UTILITY BILLS

- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Evaluating duct leakage
- Evaluating duct insulation
- Envelope infiltration
- Thermostat air sensing

##### WIDE TEMPERATURE SWINGS

- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Evaluating duct leakage
- Evaluating duct insulation
- Envelope infiltration
- Thermostat air sensing



## SINGLE AREA IS HOT OR COLD

- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Evaluating duct leakage
- Evaluating duct insulation
- Envelope infiltration
- Thermostat air sensing

## INDOOR AIR QUALITY

- Number of air changes per hour
- Odor control
- Contaminants

## ANALYZING REPORTED SYMPTOMS IN COOLING

### POOR COOLING

- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity
- Determining and interpreting the sensible heat ratio
- Evaluating duct leakage
- Using temperature drop across evaporator coil

### HUMIDITY PROBLEMS

- Interpreting wet bulb and dry bulb temperatures
- Interpreting supply / return air volume
- Determining and interpreting the sensible heat ratio
- Evaluating duct leakage

### DRAFTY

- Interpreting supply / return air temperature
- Interpreting supply / return air volume
- Interpreting supply / return air velocity

## SYSTEM COMPONENTS

### INTRODUCTION TO SYSTEMS

#### HEAT TRANSFER AND THE BASIC COOLING CYCLE

- Heat transfer and cooling
- Basic refrigeration circuit - 7 components
- Dynamic analysis of temperatures and pressure in the refrigerant circuit.
- Psychrometrics
- Subcooling
- Superheat

#### SPLIT SYSTEMS

- Introduction to split system AC configurations and applications
- Equipment locations and mounting in residential split system air conditioner applications
- Duct designs for split systems air conditioners
- Electrical layouts for split systems air conditioners
- Refrigerant circuits for split systems air conditioners
- Specifications for split system air conditioners
- Attic / Crawlspace layouts for split system air conditioners
- Closet layouts for split systems air conditioners
- Basement layouts for split systems air conditioners
- Heat options with split system air conditioners
- Ventilation options split systems air conditioners
- Regional considerations in split system air conditioner designs
- Special consideration of indoor coils above living space
- Introduction to refrigerant pipe layout in split systems air conditioners

#### PACKAGED SYSTEMS

- Introduction to package AC configurations
- Equipment locations for package air conditioners
- Basic duct designs for packaged equipment
- Electrical layouts with packaged air conditioners
- Packaged equipment in single story applications
- Packaged equipment in multi story applications
- Packaged equipment applied with crawlspace duct designs

- Heat options with packaged air conditioners
- Ventilation options for packaged air conditioners
- Economizer options
- Regional considerations in packaged equipment
- Specifications for packaged equipment
- Applications for packaged air conditioners systems

#### **MULTI-CAPACITY SYSTEMS**

- Overview of multi-capacity systems
- Sequencing of multi-capacity air conditioners
- Refrigerant circuits of multi-capacity air conditioners

#### **DUCT SYSTEMS**

##### **DUCT SYSTEMS**

- Duct system design
- Duct configurations - extended plenum, reducing extended plenum, perimeter radial, perimeter loop, overhead radial
- Return configurations - ducted, central, etc.
- Return grille locations - low sidewall, high sidewall, etc.
- Supply locations - floor, sidewall, ceiling, etc.

#### **WIRING LAYOUTS**

##### **POWER WIRING**

- Overview of power wiring

##### **LOW VOLTAGE**

- Overview of low voltage wiring

##### **CONTROL SEQUENCE**

- Overview of control sequence used in split systems
- Overview of control sequence used in packaged systems

#### **COMPONENTS**

##### **OUTDOOR COILS**

- Types - basic designs

##### **RECIPROCATING COMPRESSORS**

- Fundamentals of compressor operations
- Compressor types
- Design considerations of compressors
- Compressor components

##### **REFRIGERANTS**

- Refrigerants used in Res./Lt. Com air conditioners
- Properties of refrigerants used in Res./Lt. Com air conditioners
- Using temperature-pressure chart
- Refrigerant conservation
- Characteristics of blends, temperature glide, and fractionalization

##### **SERVICE VALVES**

- One way (front seating) service valves
- Two-way (back seating) service valves
- Gauge port

##### **REFRIGERANT CIRCUIT ACCESSORIES**

- Operation fundamentals - receivers
- Operation fundamentals - accumulators
- Operation fundamentals - filter-driers
- Operation fundamentals - sight glasses, moisture indicators, liquid indicators, etc.
- Operation fundamentals - mufflers

##### **INDOOR COILS**

- Types - basic designs and operating characteristics of A-coil, slab, and slant indoor coils
- Basics of selection
- Condensate drains

##### **METERING DEVICES - FIXED**

- Basics of operation - cap tubes
- Basics of operation - fixed restrictors
- Role of distributor in metering device performance
- Selection of pistons with fixed metering devices

##### **BLOWERS AND FANS**

- Introduction to indoor blowers
- Introduction to outdoor fans
- Indoor blowers - types and selection
- Outdoor fans - types and selection
- Blower and fan performance

#### LINE SETS

- Introduction to line sets
- Selecting line sets
- Application considerations when using line sets

#### AIR SIDE COMPONENTS

- Dampers
- Ventilation fittings
- Electronic air cleaners (EAC's)
- Electrostatic filters - non-electric
- Media type filters
- Fixed outdoor air damper
- Insulating material
- Flexible duct materials
- Economizers
- Metal duct components
- Ductboard

#### GRILLES, REGISTERS, & DIFFUSERS

- Types and uses
- Selecting diffusers, grilles, and registers

#### FASTENERS

- Screws
- Bolts
- Nuts and washers
- Lockpins
- Rivets

#### ELECTRICAL COMPONENTS

- Overcurrent protection
- Capacitors
- Solenoids
- Crankcase heaters
- Auxiliary strip heat
- Transformers

#### SCROLL COMPRESSORS

- Fundamentals of scroll compressors
- Scroll compressor components
- Design considerations of scroll compressors advanced features

#### LUBRICANTS

- Mineral oil-based refrigerants and properties
- Alkylbenzenes (AB)
- Polyolesters (POE)
- Lubricant / system compatibility
- Evaluating lubricants after removal from system
- Disposal of lubricants

#### METERING DEVICES - VARIABLE

- TEV's - types and operation, w/ check valves, bi-directional, w/ external bridge
- Role of distributors in variable metering devices
- Externally equalized
- Thermostatic charges
- Off cycle pressure equalization
- Selection of TEV's - SH setting, charge

#### START ASSIST COMPONENTS

- Introduction to start components
- Selecting start components
- Considerations in using start components
- Hard start kits - potential relay and start capacitor

Soft start PTCR assists

## CONSTANT AIRFLOW MOTORS

Intro to variable speed motors - ECM, BPM, and VSIM

Motor mounting and installation requirements

Electronic interface and setting for airflow requirements

## ELECTROMECHANICAL SENSING CONTROLS

### ELECTROMECHANICAL WALL THERMOSTATS

Basic thermostat types and operation

Thermostat terminals and wiring

Using electromechanical thermostats

Selecting wall thermostats and sub-bases

### ELECTROMECHANICAL TEMPERATURE CONTROLS

Introduction to bimetal controls

Disc type temperature limit controls

Introduction to vapor charged controls

Overview of electric heat high limits

Motor overloads

Fuses and fuse links

### PRESSURE CONTROLS

Introduction to disc type pressure controls and hi/low controls

Selection of disc type pressure controls

Using disc type pressure controls

### ELECTROMECHANICAL OUTDOOR THERMOSTATS

Overview of outdoor thermostats

Outdoor thermostat wiring

Low ambient cooling controls

## REFRIGERANT CIRCUIT CONTROLS

### PRESSURE CONTROLS

High pressure limit controls

Low pressure limit controls

## NON-SENSING CONTROLS

### RELAYS AND CONTACTORS

Introduction to relays and contactors

Basics of relay and contactor operation - inrush and holding

Selecting relays and contactors

Application considerations for relays and contactors

### ELECTRIC HEAT CONTROLS

Sequencers

## ELECTRONIC CONTROLS

### ELECTRONIC THERMOSTATS

Fundamentals of electronic thermostats

Selecting electronic thermostats

Overview of electronic thermostat operation

### ZONE CONTROLS

Fundamentals of zone controls

Selecting zone controls

Typical zone control logic

### ELECTRONIC COMPRESSOR CONTROLS

Compressor staging controls

Compressor time delays

### ELECTRONIC TIMERS

Introduction to blower delay timers

Introduction to compressor delay timers

### OVERVIEW OF ELECTRONIC CONTROLLERS

Input / output operations

Logic

## *APPLIED KNOWLEDGE: REGS, CODES, & DESIGN*

## AIR QUALITY REGULATIONS

### INDOOR AIR QUALITY

Fresh air supplies

## ELECTRICAL CODE

### REQUIREMENTS

- Overview of electrical code
- Circuit breaker and fuse requirements
- General wiring practices
- Class I wire sizing
- Class II wire sizing
- Conduit sizing
- Definitions

## STATE AND LOCAL REGULATIONS AND CODES

### STATE AND LOCAL REGULATIONS

- State requirements for technicians

### CODES

- Plumbing
- Municipalities
- HVAC for Lt. Commercial

## FIRE PROTECTION REGULATIONS AND CODES

### REQUIRED COMPONENTS

- Return air sensors
- Fire dampers

### FIRE PREVENTION

- Overview

## DESIGN CONSIDERATIONS - COMFORT

### TEMPERATURE

- Designing for capacity
- Using industry standards

### HUMIDITY

- Role of humidity in comfort
- Using industry standards

### INDOOR AIR QUALITY

- Ventilation - comfort
- Air cleaning for comfort
- Industry standards for air quality
- Outside air

### SOUND LEVEL

- Equipment location considerations
- Isolation, mounting pad, duct, and structure
- Duct systems

## DESIGN CONSIDERATIONS - COMPONENTS

### DIFFUSERS, REGISTERS, AND GRILLES

- Selecting diffusers, grilles, and registers for capacity
- Locations
- Selecting diffusers, grilles, and registers for throws, spread, and pressure drop
- Selecting diffusers, grilles, and registers for reduced sound

### ACCESSORIES

- Start components
- Filter-driers - When to use? and How to select?
- Filtering - EAC, media, HEPA, electrostatic
- Outdoor thermostats - lockout auxiliary heat
- Wall thermostat options
- Accumulators - When to use? and How to select?
- Humidifier sizing
- Time delays
- Crankcase heaters
- Low ambient cooling controls

## DESIGN CONSIDERATIONS - RES. & LT. COMM.

### SPLIT SYSTEMS

- System designs - closets, basements, etc.
- Refrigerant piping

- Equipment location
- Electrical layouts
- Duct design / balancing
- Condensate drains
- Ventilation - fresh air
- Regional design considerations
- Ventilation - equipment
- Secondary condensate drains / pans
- Mounting of equipment
- Heat options
- Specifying equipment

**PACKAGED SYSTEMS**

- Package system configurations and design
- Equipment locations design
- Applications for packaged systems
- Basic duct designs for packaged equipment
- Condensate drain piping design
- Electrical layouts with packaged air conditioners
- Packaged equipment in single story applications
- Packaged equipment in multi story applications
- Packaged equipment in crawlspace applications
- Heat options with packaged systems
- Ventilation options
- Regional considerations in packaged equipment
- Specifications for packaged equipment

**MECHANICAL CODE**

**EQUIPMENT ACCESS**

- Minimum clearance
- Electrical disconnects
- Fire dampers

**REFRIGERANT LINE ROUTING**

- Support requirements
- Inspection requirements

**CONDENSATE DRAINS**

- Materials
- Sizing

**INDUSTRY STANDARDS**

**EQUIPMENT STANDARDS**

- Introduction to industry standards
- ARI standards for ratings

**SYSTEM STANDARDS**

- Introduction to industry standards
- Industry standards

**BIDS AND PROPOSALS**

**SYSTEM SIZING**

- Survey of requirements
- Selecting equipment
- Sizing components - high / low side
- Adding accessories
- Duct sizing - new and retrofit application

**ESTIMATING INSTALLATION**

- Installation price
- Understanding proposal forms
- Understanding bid forms - bid to specs and flat rate pricing
- Legal implications of a bid

**SIZING REFRIGERANT LINES**

- Capacities of refrigerant lines - effects of improper sizing
- Effects of fittings, pressure drop, and insulation on system performance

**ELECTRICAL**

- Effects of electrical power on system devices







# TEMPERATURE PRESSURE CHART-atsealevel



Pressure (PSIG), Vacuum (in. Of Hg)-**Bold Italic** Figures

To determine subcooling for 404A, 407C, and 4220, use BUBBLE POINT values (temperatures above 50°F -gray background)

To determine superheat for 404A, 407C, and 4220, use DEW POINT values (temperatures 50°F and below)

TEMP.		REFRIGERANT						
Of	OC	22	134a	404A	407C	410A	4220	507
-40	-40.0	0.6	<i>14.8</i>	4.3	4.6	10.7	2.3	5.4
-38	-38.9	1.4	<i>13.9</i>	5.3	3.2	12.0	0.8	6.4
-36	-37.8	2.2	<i>13.0</i>	6.3	1.6	13.4	0.4	7.5
-34	-36.7	3.1	<i>12.0</i>	7.4	0.0	14.8	1.2	8.6
-32	-35.6	4.0	<i>10.9</i>	8.5	0.8	16.2	2.1	9.8
-30	-34.4	4.9	9.8	9.6	1.6	17.8	3.0	11.0
-28	-33.3	5.9	8.7	10.8	2.5	19.3	3.9	12.2
-26	-32.2	6.9	7.5	12.0	3.5	21.0	4.9	13.5
-24	-31.1	8.0	6.3	13.3	4.4	22.7	5.9	14.8
-22	-30.0	9.1	5.0	14.6	5.4	24.4	7.0	16.2
-20	-28.9	10.2	3.7	16.0	6.5	26.3	8.1	17.6
-18	-27.8	11.4	2.3	17.4	7.6	28.1	9.2	19.1
-16	-26.7	12.6	0.8	18.9	8.7	30.1	10.4	20.6
-14	-25.6	13.9	0.4	20.4	9.9	32.1	11.7	22.2
-12	-24.4	15.2	1.1	22.0	11.1	34.2	12.9	23.8
-10	-23.3	16.5	1.9	23.6	12.3	36.4	14.3	25.5
-8	-22.2	17.9	2.8	25.3	13.7	38.6	15.6	27.3
-6	-21.1	19.4	3.6	27.0	15.0	40.9	17.1	29.1
-4	-20.0	20.9	4.6	28.8	16.4	43.3	18.5	30.9
-2	-18.9	22.4	5.5	30.7	17.9	45.8	20.1	32.8
0	-17.8	24.0	6.5	32.6	19.4	48.3	21.6	34.8
1	-17.2	24.9	7.0	33.6	20.2	49.6	22.5	35.8
2	-16.7	25.7	7.5	34.6	21.0	51.0	23.3	36.9
3	-16.1	26.5	8.0	35.6	21.8	52.3	24.1	37.9
4	-15.6	27.4	8.5	36.6	22.6	53.7	25.0	39.0
5	-15.0	28.3	9.1	37.7	23.5	55.0	25.8	40.0
6	-14.4	29.2	9.6	38.7	24.3	56.5	26.7	41.1
7	-13.9	30.1	10.2	39.8	25.2	57.9	27.6	42.2
8	-13.3	31.0	10.8	40.9	26.1	59.3	28.5	43.4
9	-12.8	31.9	11.3	42.0	27.0	60.8	29.5	44.5
10	-12.2	32.8	11.9	43.1	27.9	62.3	30.4	45.7
11	-11.7	33.8	12.5	44.3	28.8	63.8	31.3	46.8
12	-11.1	34.8	13.1	45.4	29.8	65.4	32.3	48.0
13	-10.6	35.8	13.8	46.6	30.7	66.9	33.3	49.3
14	-10.0	36.8	14.4	47.8	31.7	68.5	34.3	50.5
15	-9.4	37.8	15.0	49.0	32.7	70.1	35.3	51.7
16	-8.9	38.8	15.7	50.2	33.7	71.7	36.4	53.0
17	-8.3	39.9	16.4	51.5	34.7	73.4	37.4	54.3
18	-7.8	40.9	17.0	52.7	35.7	75.1	38.5	55.6
19	-7.2	42.0	17.7	54.0	36.8	76.8	39.6	56.9
20	-6.7	43.1	18.4	55.3	37.9	78.5	40.7	58.2
21	-6.1	44.2	19.1	56.6	39.0	80.3	41.8	59.6
22	-5.6	45.3	19.9	58.0	40.1	82.0	42.9	61.0
23	-5.0	46.5	20.6	59.3	41.2	83.8	44.1	62.4
24	-4.4	47.6	21.3	60.7	42.3	85.7	45.2	63.8
25	-3.9	48.8	22.1	62.1	43.5	87.5	46.4	65.2
26	-3.3	50.0	22.9	63.5	44.7	89.4	47.6	66.7
27	-2.8	51.2	23.7	64.9	45.9	91.3	48.8	68.2
28	-2.2	52.4	24.5	66.4	47.1	93.2	50.1	69.7
29	-1.7	53.7	25.3	67.8	48.3	95.2	51.3	71.2
30	-1.1	55.0	26.1	69.3	49.6	97.2	52.6	72.7
31	-0.6	56.2	26.9	70.8	50.8	99.2	53.9	74.3

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# TEMPERATURE PRESSURE CHART-atsealevel



Pressure (PSIG), Vacuum (in. Of Hg)-**Bold Italic Figures**

To determine subcooling for 404A, 407C, and 4220, use BUBBLE POINT values (temperatures above 50°F -gray background)

To determine superheat for 404A, 407C, and 4220, use DEW POINT values (temperatures 50°F and below)

TEMP.		REFRIGERANT						
•F	OC	22	134a	404A	407C	410A	4220	507
32	0.0	57.5	27.8	72.4	52.1	101.2	55.2	75.8
33	0.6	58.8	28.6	73.9	53.4	103.3	56.5	77.4
34	1.1	60.2	29.5	75.5	54.8	105.4	57.9	79.0
35	1.7	61.5	30.4	77.1	56.1	107.5	59.3	80.7
36	2.2	62.9	31.3	78.7	57.5	109.7	60.6	82.3
37	2.8	64.3	32.2	80.3	58.9	111.9	62.0	84.0
38	3.3	65.7	33.1	82.0	60.3	114.1	63.5	85.7
39	3.9	67.1	34.1	83.7	61.7	116.3	64.9	87.5
40	4.4	68.6	35.0	85.4	63.2	118.6	66.4	89.2
42	5.6	71.5	37.0	88.8	66.1	123.2	69.4	92.8
44	6.7	74.5	39.0	92.4	69.2	127.9	72.5	96.4
46	7.8	77.6	41.1	96.0	72.3	132.8	75.6	100.2
48	8.9	80.8	43.2	99.8	75.5	137.8	78.9	104.0
50	10.0	84.1	45.4	103.6	78.8	142.9	82.2	108.0
52	11.1	87.4	47.7	109.2	101.7	148.1	96.1	112.0
54	12.2	90.8	50.0	113.3	105.6	153.5	99.8	116.1
56	13.3	94.4	52.4	117.4	109.6	159.0	103.6	120.4
58	14.4	98.0	54.9	121.7	113.7	164.7	107.4	124.7
60	15.6	101.6	57.4	126.0	117.9	170.4	111.4	129.1
62	16.7	105.4	60.0	130.5	122.3	176.3	115.4	133.7
64	17.8	109.3	62.7	135.0	126.7	182.4	119.5	138.3
66	18.9	113.2	65.4	139.7	131.2	188.6	123.8	143.1
68	20.0	117.3	68.2	144.4	135.8	194.9	128.1	147.9
70	21.1	121.4	71.1	149.3	140.5	201.4	132.5	152.9
72	22.2	125.7	74.1	154.3	145.4	208.0	137.1	158.0
74	23.3	130.0	77.1	159.4	150.3	214.8	141.7	163.2
76	24.4	134.5	80.2	164.6	155.4	221.8	146.5	168.5
78	25.6	139.0	83.4	169.9	160.5	228.9	151.3	174.0
80	26.7	143.6	86.7	175.4	165.8	236.1	156.3	179.5
82	27.8	148.4	90.0	181.0	171.2	243.6	161.3	185.2
84	28.9	153.2	93.5	186.7	176.8	251.2	166.5	191.0
86	30.0	158.2	97.0	192.5	182.4	258.9	171.8	197.0
88	31.1	163.2	100.6	198.4	188.2	266.8	177.2	203.0
90	32.2	168.4	104.3	204.5	194.1	274.9	182.7	209.2
92	33.3	173.7	108.1	210.7	200.1	283.2	188.4	215.5
94	34.4	179.1	112.0	217.0	206.3	291.6	194.1	222.0
96	35.6	184.6	115.9	223.4	212.5	300.3	200.0	228.6
98	36.7	190.2	120.0	230.0	219.0	309.1	206.0	235.3
100	37.8	195.9	124.2	236.8	225.5	318.1	212.1	242.2
102	38.9	201.8	128.4	243.6	232.2	327.2	218.4	249.2
104	40.0	207.7	132.7	250.8	239.0	336.6	224.8	256.3
106	41.1	213.8	137.2	257.8	245.9	346.2	231.3	263.7
108	42.2	220.0	141.7	265.1	253.0	355.9	237.9	271.1
110	43.3	226.4	146.4	272.5	260.3	365.9	244.7	278.7
112	44.4	232.8	151.1	280.1	267.6	376.1	251.6	286.5
114	45.6	239.4	156.0	287.9	275.1	386.4	258.8	294.4
116	46.7	246.1	160.9	295.8	282.8	397.0	265.8	302.4
118	47.8	253.0	166.0	303.8	290.6	407.8	273.2	310.7
120	48.9	260.0	171.2	312.1	298.6	418.8	280.6	319.1
125	51.7	278.0	184.6	333.3	319.2	447.4	299.9	340.8
130	54.4	296.9	198.7	355.6	340.7	477.4	320.2	363.6